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"PIPE SECTION FOR A PIPE COIL"

[0001] The invention deals with tube portions for a tube coil, in particular for tube coils for chemical plants, for example petrochemical plants such as ethylene crackers.

[0002] It is known in ethylene crackers for the medium which is to be cracked to be passed through a heating space, for example a furnace, in a multiply bent tube coil. These tube coils are partly made up of rectilinear tubes, which in order to form a continuous tube coil are connected to one another in their end regions by means of bent tube portions connected to the straight tubes by joining methods.

[0003] Part of a tube coil of this type which is known from the prior art is illustrated by way of example in Figs 1 and 2. In this tube coil, the tubes are connected to one another by bent tube portions referred to as fittings. The fittings are produced, for example, by static casting and form a single tube bend. The fittings are welded onto tubes at their ends.

[0004] In the context of the present invention, the term tube bend is to be understood as meaning the region of a curved tube in which the orientation of the longitudinal axis of the tube is changing continuously. The tube bend ends at the point beyond which the orientation of the longitudinal axis of the tube does not change any further.

[0005] The tube coils of the prior art have a wide range of weld seams which are required in order to connect the single-bend fittings to the tubes. This makes the tube coils complex to produce. Moreover, weld seams form potential weak points for the formation of cracks in a tube coil of this type. Since the fittings and tubes of the known tube coils often consist of different material structures,

production costs are increased further by the difficulty of welding together different metals. Moreover, the fittings produced by static casting generally have a high weight, and consequently if the tube coil is suspended in a furnace, for example an ethylene cracker, there is a considerable load on the suspension means, or else there will be high levels of creep (lengthening) of the tubes. Moreover, the manufacturing-related increased wall thickness of the fittings leads to poor heat transfer between the heating medium surrounding the tube coil and the medium that is to be treated and is passed through the tube coil. Moreover, the high wall thickness, on account of the temperature gradient, leads to additional stresses, which can lead to cracks in the fittings.

[0006] In view of this background, the invention is based on the object of providing a tube bend which makes it easy to join together a tube coil.

[0007] This object is achieved by the independent claims. Advantageous configurations of the invention are given in the subclaims.

[0008] The invention builds on the basic concept of providing the tube portion with a plurality of tube bends. This makes it possible, for example, to produce a connection between two tubes running parallel to and at a distance from one another by means of a single-piece, metallic tube portion. There is no need for two tube portions with a single bend to be connected to an intermediate tube in order to produce this connection, and consequently the number of weld seams is reduced.

[0009] According to the invention, the term tube portion is to be understood as meaning a body which is produced by deformation from a single-piece tube. This tube portion is distinct from such subsections of a tube coil which are combined by joining methods, for example welding, to form a multiply bent subsection of the tube coil.

[0010] In the context of the present invention, the term longitudinal axis is to be understood as meaning the line which connects the center points of the area of the cross sections, taken perpendicular to the direction of flow of the medium guided in the tube portion, of the cavity provided in the tube portion for the medium to flow through. These cross sections are preferably circular or elliptical.

[0011] It is preferable for the longitudinal axis of the tube portion not to run in one plane between two ends of the tube portion. This makes it possible to use the tube portion to produce subsections of a tube coil which are matched to specific design requirements of the furnace, for example of the cracker. The tube portion according to the invention may have more than two ends, for example in a forked arrangement.

[0012] A particularly compact design of a tube coil can be achieved if the ratio of bending radius to the tube diameter of the tube bend, at least in sections, is less than 1.5, preferably, at least in sections, is less than 1.1 and particularly preferably, at least in sections, is equal to 1.04.

[0013] The tube portion according to the invention can be used to produce a particularly compact tube coil if the intermediate lengths between two tube bends of a tube portion are kept short, preferably less than 300 mm, particularly preferably less than 100 mm, and especially preferably equal to 40 mm. The intermediate length is the term used to refer to the length of the subsection of the tube portion according to the invention located between two tube bends, in which the orientation of the longitudinal axis of the tube portion does not change.

[0014] It is particularly preferable for the tube portion to be produced from one of the following DIN EN 10027 Part 1 materials types (materials number in accordance with SEW595 and E DIN 17465; or ASTM type):
GX40CrNiSi25-20 (1.4848; HK 40*),

GX35CrNiSiNb24-24 (1.4855),
GX45NiCrSi35-25 (1.4857; HP*),
GX43NiCrWSi35-25-4 (HP+W*),
GX40NiCrSiNb35-25 (1.4852; HP+Nb*),
GX45NiCrSiNbTi35-25 (HP+Nb Micro*),
GX10NiCrNb32-20 (1.4859; CT 15C*),
GX50CrNiSi30-30 (1.4868),
G-NiCr28W (2.4879),
GX45NiCrSiNb45-35,
GX13NiCrSiNb45-35,
GX13NiCrNb37-25,
GX55NiCrWZr33-30-4.

[0015] Uniform treatment of the medium passed through the tube portion is achieved if the subregions of the tube portion have substantially the same diameter and/or wall thickness. Moreover, the configuration of the tube portion with a substantially constant wall thickness reduces the stresses in the tube portion.

[0016] It is particularly preferable for the wall thickness to be between 6 mm and 14 mm along the entire tube portion. By way of example, the tube wall thickness of the entire tube portion is at least 8 mm in the region of the tube bend which is under tension and at most 11 mm in the region of the tube bend which is under compression.

[0017] In an advantageous configuration of the invention, the inner surface of the tube portion, at least in part, has a roughness of less than 12 R_a, in particular at least in part has a roughness of approx. 3.2 R_a. The reduction in the roughness of the inner surface, when the tube portion is used in tube coils forming part of a petrochemical plant in which hydrocarbons are treated in the tube coil, minimizes the deposition of coke particles on the inner surface (coking) and the

diffusion of carbon into the interior of the material (carburization). Moreover, the formation of a uniform, dense protective layer of chromium oxide on the inner surface of the tube portion is promoted by the smooth surface.

[0018] A tube coil according to the invention for a chemical plant which is assembled from metallic tubes produced integrally and connected to one another by tube portions has at least one tube portion according to the invention as described above connected to one of the tubes at least at one of its ends. This tube coil is easy to produce, since tubes which run parallel to one another can easily be connected to one another with a small number of weld seams by the multiply bent tube portions.

[0019] This connection of a tube portion to another tube portion or a tube by means of at least one of its ends is especially easy if the tube portions or the tube portion and the tube are made from the same material. On account of having the same macrostructure, the tubes can then easily be welded to one another.

[0020] Moreover, the tubes and the tube portions have the same mechanical properties and the same resistance to carburization and coking. This makes it easier to plan for the replacement of tube coils or parts of tube coils.

[0021] In a process according to the invention for producing the abovementioned tube portion or the abovementioned tube coil, at least one tube portion is produced from a centrifugally cast tube. This leads to flexibility in production of the tube portions, in particular as a fitting substitute, since there is no need to make up or alter a model of the fittings to be cast, but rather the tube portion can be bent directly into the desired configuration. The increased flexibility also manifests itself through the fact that tube portions with greater diversion radii can be produced without major outlay for plants which are subject to particularly high levels of coke erosion. Since the decoking process in petrochemical plants

uses oxygen and steam to burn off coke which has been deposited in the interior of the tube, thereby producing coke particles, in this case a high level of erosive abrasion is generated with small diversion radii. This damage to the inner side of the tube portions can be reduced by the use of greater diversion radii.

[0022] Tube portions made from tubes produced by centrifugal casting have a fine, globular macrostructure in the region of the inner surface, which has a better resistance to carburization than the columnar structure which is present in conventional fittings. Moreover, the fine structure serves as a crack stopper in the event of creep damage occurring. Moreover, on account of their high rotational speed during the production process, tubes produced by centrifugal casting have a much higher purity than castings formed by static casting.

[0023] On account of the multiply bent tube portion being produced from a straight tube produced by centrifugal casting, for example by a joining process, it is possible for the inner surface of the tube portion to be machined while the tube is still straight, i.e. before the tube portion is produced, with the result that a very smooth, homogeneous inner surface can be produced. This cannot be achieved with the fittings which have already been produced with tube bends on account of the manufacturing conditions used in static casting processes. Moreover, if the tube portion is produced by centrifugally cast tubes, additional surface treatment of the inner surface, for example by roller-burnishing, is readily possible.

[0024] It is particularly preferable for the tube portion to be produced by inductive bending of a centrifugally cast tube. In this case, it is possible to use centrifugally cast tubes, the outer surface of which has not been treated following the centrifugal casting.

[0025] Particularly in order to minimize the occurrence of cold work-hardening during the subsequent internal machining operation of the tubes, the

centrifugally cast tube is heat-treated, in particular by solution annealing or stress-relief annealing, prior to the inductive bending. It is particularly preferable for a temperature range of 800° to 1200°, in particular from 850° to 1100°, to be selected for the heat treatment. The heat treatment preferably ensures that phases which lead to embrittlement of the material (γ') are dissolved. The heat treatment can also keep the quantity of primary and secondary carbide precipitations at a low level.

[0026] According to the invention, the tube portion according to the invention described above is used as a fitting substitute for tube coils. In particular, fittings which need to be replaced in existing tube coils can be replaced with the tube portions according to the invention.

[0027] According to the invention, the tube portion described above or a tube coil described above is used in a petrochemical plant, preferably in a cracker, particularly preferably in an ethylene cracker.

[0028] In the text which follows, the invention is explained in more detail on the basis of a drawing which illustrates an exemplary embodiment. In the drawing:

[0029] Fig. 1 shows a plan view from above of a conventional tube portion of a tube coil,

[0030] Fig. 2 shows a conventional tube portion of a tube coil in a view from below,

[0031] Fig. 3 shows a tube portion according to the invention of a tube coil in a plan view from above, and

[0032] Fig. 4 shows a tube portion according to the invention of a tube coil in a view from below.

[0033] In the case of the tube portion which has been used hitherto and is illustrated in Figs 1 and 2, the tube portion comprises three individual pieces in the form of two fittings 1, 2 and one intermediate tube 3, which are connected to one another by circular weld seams 4. At their other ends, the fittings 1, 2 are connected to straight tubes 5, 6 of the tube coil by circular weld seams 7.

[0034] The greater thickness of the fittings 1, 2 compared to the intermediate tube 3 is clearly apparent. These fittings 1, 2 produced by the conventional casting process have a greater wall thickness than the intermediate tube, resulting in different heat transfer. Moreover, the conventional tube portion illustrated is complex to produce on account of the circular weld seams.

[0035] The tube portion according to the invention is illustrated in Figs 3, 4. It is produced as a single piece from a centrifugally cast tube by inductive bending. The longitudinal axis A of the tube portion changes continuously between points B and C and between points D and E. Between the points C and D there is an intermediate region in which the orientation of the longitudinal axis of the tube does not change. Accordingly, the tube portion 10 according to the invention has two tube bends 11, 12. As will be apparent if Figures 3 and 4 are considered in combination, the longitudinal axis A does not run in one plane between points B and E. The tube portion 10 is connected to straight tubes 13, 14 of a tube coil by means of circular weld seams 15.